# L1551NE - Discovery of a Binary Companion


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## 1. Introduction

Young T Tauri stars in Taurus have been found to have a high incidence of multiplicity, with the fraction of close ($\lesssim$100A.U.) companions found to be 0.40 ± 0.08 (Ghez et al. 1993; Leinert et al. 1993; Simon et al. 1995; Patience et al. 1998), using speckle and occultation techniques. Similar surveys of the Hyades cluster found a smaller fraction of 0.30 ± 0.06, and a still lower fraction of 0.14 ± 0.03 for G dwarfs in the solar neighborhood (Patience et al. 1998), suggesting an evolutionary effect and/or environmental effects during formation. Deeply embedded class I and class 0 protostars cannot be surveyed using similar techniques, since they are not visible at optical wavelengths and are generally too deeply embedded even at infrared wavelengths. Millimeter/sub-millimeter-wavelength interferometry at sub-arcsecond resolution can resolve close companions if they have circumstellar disks. For example, L1551 IRS5 was recently shown to be a binary based on 7mm interferometric observations at the VLA (Rodríguez et al. 1998). We present here evidence that L1551 NE also has a binary companion.

L1551NE (B1950 $4^h28^m50.5^s$ +18°02′10″ (Draper, Warren-Smith & Scarrott 1985)) is a young stellar object in the L1551 molecular cloud, at a distance of 160 pc (Snell 1981). Discovered by Emerson et al. (1984) from IRAS data, it is the second brightest embedded source in the Taurus complex after L1551 IRS5, with $L_{bol} \sim 6L_{\odot}$. It has a molecular outflow (Moriarty-Schieven, Butner & Wannier 1995). The radial density distribution of L1551NE has been modeled by Barsony & Chandler (1993) from 800$\mu m$ images, and by Butner et al. (1995) from 100$\mu m$ and 200$\mu m$ observations. Both found that the density distribution implied by the radial intensity profile was much shallower than the $n(r) \sim r^{-1.5}$ predicted by the "inside-out" collapse model of Terebey, Shu & Cassen (1984). Moriarty-Schieven, Butner & Wannier (1995) have suggested that L1551 NE may be a class 0 source.

east of the primary source, and surrounding source B.

To verify that we are seeing real sources and not phase instabilities, we generated images using the same techniques of another source, IRAS 04169+2702, which was observed during the same two days and interspersed with L1551NE. Phase errors would be manifested as "anomalous" sources or structures. No such anomalous sources are seen in the image of IRAS 04169+2702. In addition, we cleaned the "$l$" configuration data separately from the "$h$" configuration data. The high-resolution data clearly had two peaks, while the low-resolution data showed an extended disk-like structure with long axis through the line joining the two sources. Thus we believe that the structure seen here in L1551NE is real.

In Table 1 we present the positions, sizes and flux densities of the sources. The single-dish flux density at 1.35mm is also shown.

## 4. Discussion

There are three distinct components apparent in the image shown in Figure 1; a brighter, possibly extended source at the field center (source A), a weaker, probably point-like source (B) 1.43" south-east of A, and diffuse, low-level emission which appears to surround both sources and extend ~2" to the northwest and east of A.

Sources A and B were fit with elliptical gaussians using the *AIPS* task JMFIT. The primary source A was found to have a size 1.53"x1.28" (i.e. it may have been slightly resolved with a size $\sim 2\sigma$ larger than the beamsize), peak intensity $\sim$ 0.33 Jy and integrated intensity $\sim$ 0.47 Jy (i.e. ~40% ($\sim 3\sigma$) larger than the peak intensity). If it is slightly resolved (deconvolved size $\sim$ 0.82"x0.70"), then its size is ~131x112 A.U. at a distance of 160pc. Source B is located 1.43" (229 A.U. at 160pc) south-east of A, and its size and intensity are consistent with it being unresolved, i.e. <100 A.U. We estimate the mass

Weak, low-level emission can be seen extending ~1-2" to the north and east of source A, and perhaps encompassing source B. This extended structure has a disk-like appearance, of dimension $\sim 5'' \times 2''$ (~800x300pc with long axis at position angle ~-12°. This is roughly perpendicular to the axis of the conical reflection nebula emanating from L1551NE (Draper et al. 1985; Hodapp 1995), and hence of the molecular outflow (Moriarty-Schieven et al. 1995). This disk-like structure may represent a circum-binary disk.

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Simon, M., Ghez, A. M., Leinert, Ch., Cassar, L., Chen, W. P., Howell, R. R., Jameson, R. F., Matthews, K., Neugebauer, G., & Richichi, A. 1995, ApJ, 443, 625

Snell, R. L. 1981, ApJS, 45, 121

Terebey, S., Shu, F. H., & Cassen, P. 1984, ApJ, 286, 529

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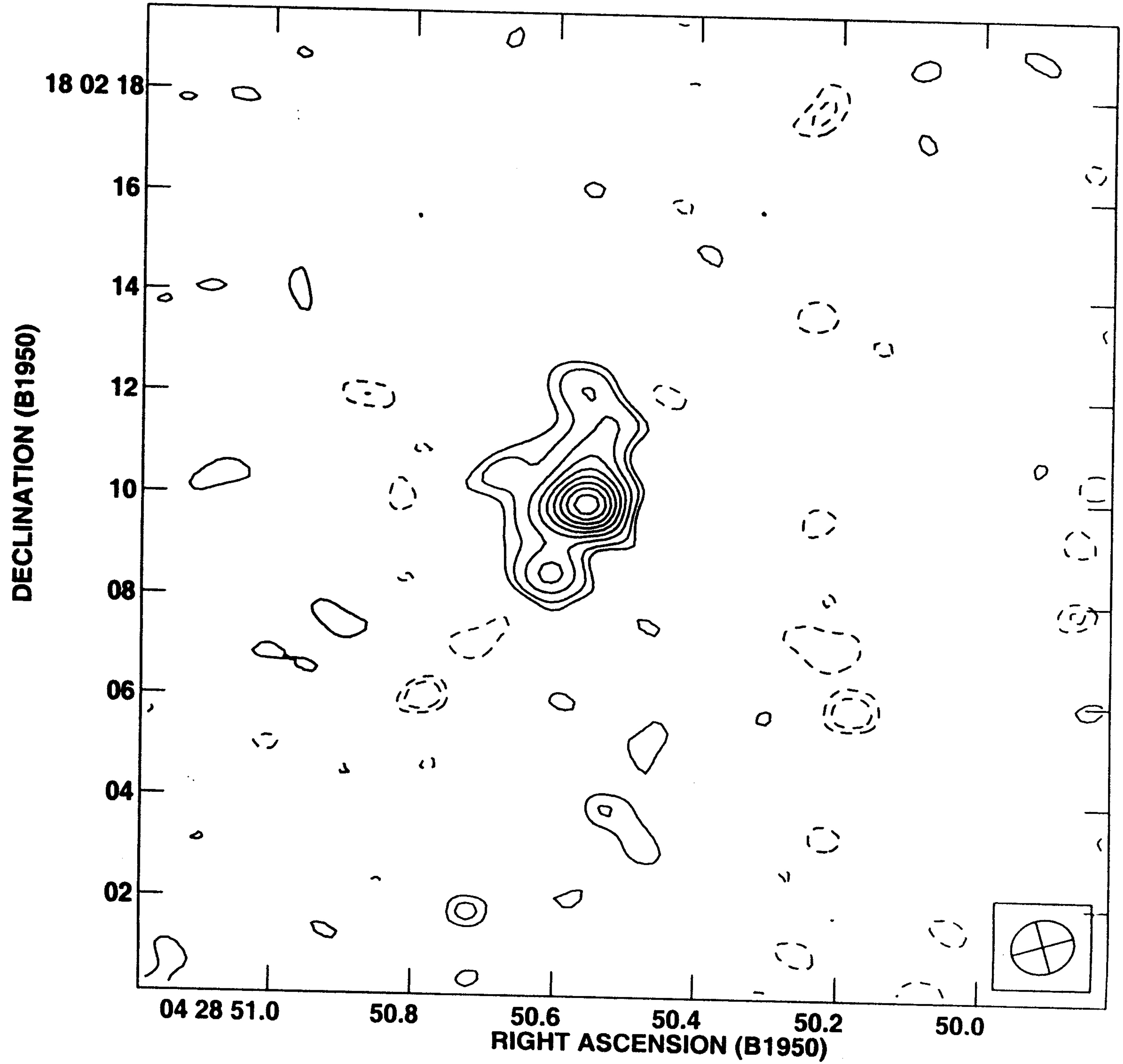
Table 1: Source Parameters

| | |
|---|---|
| **Source A** | |
| Peak Intensity | 0.333 ± 0.022 Jy/beam |
| Integrated Intensity | 0.473 ± 0.049 Jy |
| Position (B1950) | $04^h28^m50.559^s$ 18°02'09.91" (± 0.1") |
| Size | 1.53" × 1.28" ± 0.1" P.A. 104° ± 15° |
| "Deconvolved" Size | 0.82" × 0.70" (131 × 112 A.U. at 160pc) |
| Mass[a] | 0.044 $M_\odot$ |
| **Source B** | |
| Peak Intensity | 0.146 ± 0.022 Jy/beam |
| Integrated Intensity | 0.197 ± 0.048 Jy |
| Position (B1950) | $04^h28^m50.604^s$ 18°02'08.64" (± 0.17") |
| Mass[a] | 0.014 $M_\odot$ |
| **Circumbinary Disk** | |
| Integrated Intensity | 0.233 ± 0.048 Jy |
| Size | 5.51" (± 0.44") × 2.59" (± 0.22") P.A. 2° (± 14°) |
| Deconvolved Size | 5.4" (± 0.3") × 2.3" (± 0.2") P.A. 2° (± 10°) |
| Mass[a] | 0.022 $M_\odot$ |
| **Total Integrated Intensity** | |
| Integ. Intensity | 0.851 ± 0.084 Jy |
| Mass[a] | 0.079 $M_\odot$ |
| **Single Dish Intensity[b]** | |
| 19" FWHM beam | 0.83 ± 0.03 Jy |
| Mass[a] | 0.078 $M_\odot$ |

[a]Assuming $T_d$=42K, $M_g/M_d$=100, D=160pc.

[b]From Butner et al. (2000). Obtained with 14m JCMT (20" FWHM)).



18 02 18
16
14
12
10
08
06
04
02
DECLINATION (B1950)
04 28 51.0
50.8
50.6
50.4
50.2
50.0
RIGHT ASCENSION (B1950)